Evaluation of economic rent from hydroelectric power developments: Evidence from Cameroon

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Abstract

The exploitation of hydro resources for generating electricity at cheaper cost gives rise to significant economic rent to owners. Cameroon, which has a great hydropower potential is engaged in developing the resources. Thus, the main goal of this study is to calculate the potential economic rent that could be generated in the Cameroonian hydropower sector in order to meet the electricity needs and to achieve the "Cameroon 2035 Vision" promoted by the Government. In this study the hydropower rent is calculated for the whole country as the difference between optimized total costs of two hypothetical systems: one with hydropower and the other without hydropower. We also analyse the sensitivity of the rent estimation due to variations in some key parameters. Using the LEAP software system, our calculation gives a value of 16.937 Euro/MWh of hydropower rent for the Median scenario concerning the future demand trends. This rent is in the range of values found by Amundsen and Tjøtta (1993), Banfi et al. (2005) and Shrestha and Abeygunawardana (2009) for Norway, Switzerland and Nepal respectively.

Keywords: Economic rent, hydropower, Cameroon.

1. Introduction

Hydropower is the electric power obtained by converting the hydraulic energy of the different flows of water (rivers, ocean currents and waterfalls). From an economic viewpoint, a hydropower plant differs from a conventional thermal plant; because its initial investment cost per kW is much higher but the operating costs are extremely low, since there is no need to pay for fuel or in some countries for water rights. Thus, the exploitation of hydro resources for generating electricity is economically attractive and gives rise to significant economic rent to owners.

In the past, governments have usually claimed ownership of hydroelectric resources and passed on the rents to their state-owned utilities, which have used them to expand their systems or provide lower tariffs to their consumers. With the restructuring of the electric power sector in many countries, a more explicit consideration of hydroelectric rents is required. Moreover, hydropower resources are often owned by more than one party, or at least require cooperation between parties to develop them. In this context, the measurement and apportionment of hydropower rents between cooperating parties becomes important (Rothman, 2000).

Cameroon, which has a great potential of hydropower is engaged in the development of such resources. Thus, the aim of this study is to calculate the potential economic rent that could be generated in order to meet the electricity needs and to achieve the “Cameroon 2035 Vision” promoted by the Government. However, public authorities are facing difficulties to attract private investment. Indeed, in addition to legal, political and macroeconomic risks also encountered in other infrastructure industries, the Cameroonian electricity sector is characterized by regulated tariffs too low for operators, but too high for poor people in rural and suburban areas.

The structure of the paper is as follows: In Section 2 we introduce the concept of rent in the hydroelectric power and present different methods for calculating the rent as they have been used in other studies. Section 3 describes the power sector in Cameroon and the Government strategy to cope with the growth of electricity demand. Section 4 contains information on the data set and the methods used to estimate the rent of hydropower plants in Cameroon. Section 5 outlines the main results and the effects of variations in some key parameters on the rent. The final Section 6 is devoted to conclusions and limitations of the study.

2. Rent in the hydroelectric power

2.1 – Definitions

The concept of rent has evolved considerably since David Ricardo's classic examination in his *Principles of Political Economy and Taxation*, first published in 1817. Building on the work of the late seventeenth-century mercantilists, the physiocrats, Adam Smith, David Hume and others, Ricardo espoused a notion of land rent that has been expanded and refined into the modem concept of economic rent (Rothman, 2000). Economic rent is the surplus return (earnings or profit) that some factors of production generate when they vary in quality and are limited in supply. Surplus means that the return is more than what the factor could earn in its next best occupation. In other words, the return is greater than needed to keep the factor in that use or a reward in excess of that required to bring forth a desired effort or function. If all factors of production were of the same quality, none could earn a surplus return since factors could be interchanged. Furthermore, if the factors were available in limitless quantities, they would earn no return at all. Thus, economic rent arises from two main sources: differences in quality of factors of production (differential rent) and scarcity (scarcity rent).

- Differential rent is often called Ricardian rent since that is the type of rent discussed in David Ricardo's classic treatment of the subject. It arises when the fulfillment of demand requires simultaneously bringing into service resources of different qualities. In the case of land, sources of differential rent include soil fertility and proximity to markets. Resource extraction activities, such as mining and oil and gas production, can generate differential rent from differences in the grade of ore, petroleum or gas, proximity to the surface (ease of extraction), the need for environmental mitigation measures, etc.
- Scarcity rent – called absolute rent by Karl Marx – is rent that a landowner could earn on land that generated no differential rent. It refers to the price paid for the use of the homogeneous land when its supply is limited in relation to demand. If all land is homogeneous but demand for land exceeds its supply, the entire land will earn economic rent by virtue of its scarcity. In this way, rent will arise when supply of land is inelastic. Thus, scarcity rent occurs when limits on the supply of a resource allow producers to charge prices greater than their marginal costs.

Differential and scarcity rent at hydroelectric sites

Hydroelectric generation relies on the exploitation of nature's resources and, therefore, can be expected to give rise to economic rent. Rent at hydroelectric sites can result from the limited number of sites that are suitable for hydroelectric development, as well as the ability of some hydroelectric sites to generate electricity at lower cost than other alternative generation technologies. This implies that hydro rent can include both differential rent and scarcity rent (Rothman, 2000) or (Hartwick and Olewiler, 1998).

Differential rent arises since hydro is often a low-cost option for power generation. Just as the highest-cost mine regulates the differential rent that can be earned at lower-cost mines, the marginal production cost of alternative sources of electricity limits the differential rent that can be earned on hydro sites.

Scarcity rent also accrues from hydro sites, although the rationale is perhaps less intuitive than the rationale for differential rent. Hydro sites produce an output (electricity) for which there are abundant opportunities to produce using non-hydro production methods (gas, oil, coal, nuclear, geothermal, wind turbine and solar among them). Scarcity rent will arise if the marginal generation source can produce only limited quantities of electricity (i.e., is subject to scarcity limitations itself). Scarcity rent also arises from the seasonal limitations on the amount of water contained in a dam. Within any given season, one would expect the limited water to be managed and consumed according to its "water value" inclusive of a scarcity rent (Amundsen et al., 1992).

Figure 1: Economic rent at hydroelectric developments

(Adapted from [Rothman, 2000] and [Banfi et al., 2005])

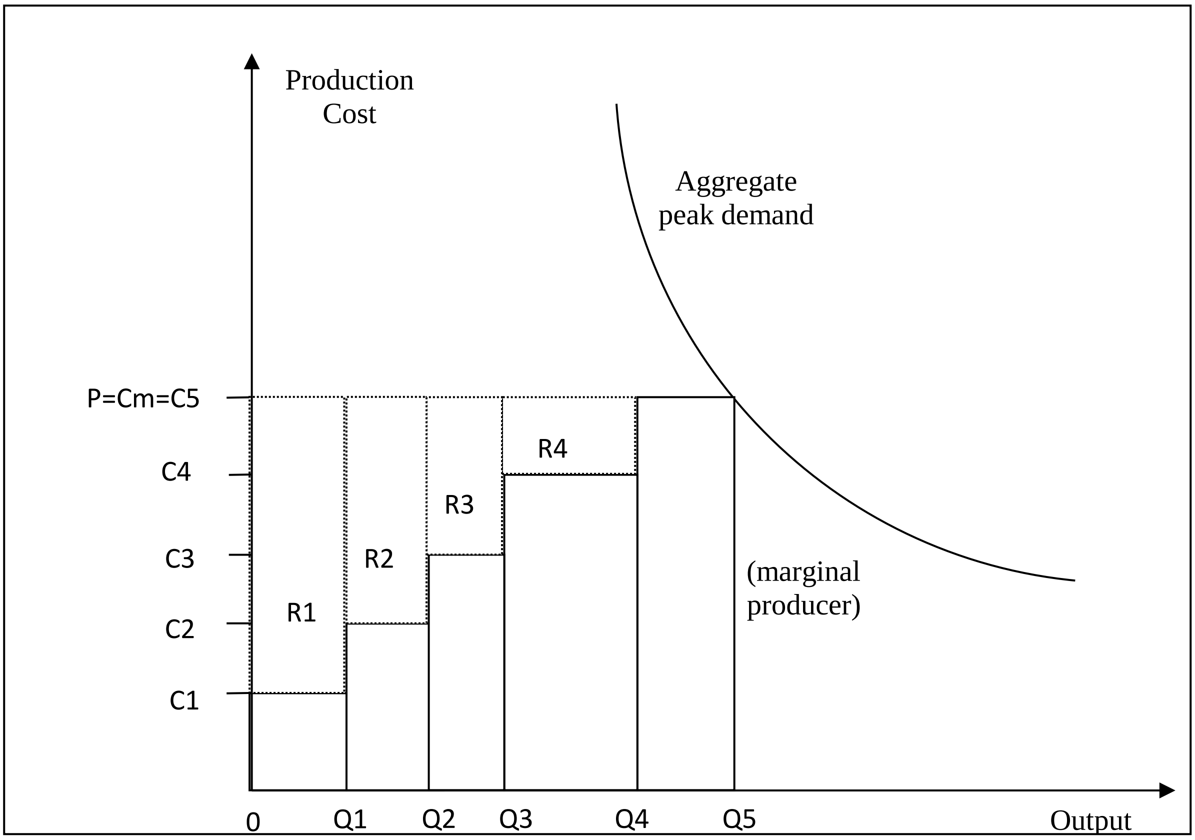


Figure 1 illustrates rents arising from alternative electricity generation technologies. Total economic rent from any given source of electricity generation is the difference between the marginal cost of production (denoted Cj) and the price for electricity that would obtain in a fully competitive market for electricity (P). Competitive markets would establish electricity prices at the marginal production cost of the marginal source used in an efficient electricity generation system. Assuming there are five sources of electricity (Qj), economic rent (Rj) arises from each with the exception of the marginal source. The rent will depend on the time of production, since demand and therefore value of the electricity fluctuates according to the load duration curve. Each hydro site could be classified as a different source of electricity and generate its own level of rent depending on the site-specific marginal production cost.

2.2 – Review of literature

The applied economic literature on the resource rent of hydropower is surprisingly small. The few published studies concern Canada ([Bernard et al., 1982], Zuker and Jenkins [1984], Gillen and Wen [2000]), Norway (Amundsen and Tjøtta, 1993), Switzerland (Banfi et al., 2005), Nepal (Shrestha and Abeygunawardana, 2009), Lao PDR (Boungnong and Phonekeo, 2012) and Italy (Massarutto and Pontoni, 2015).

As with other forms of rent, measuring hydro rent is, conceptually, simple. As shown in Figure 1, hydropower rent is the competitively determined electricity price minus the marginal cost of producing the hydroelectric power. Unfortunately, neither of these values is readily observable in jurisdictions with public utilities and regulated tariffs. Regulated electricity tariffs, typically set at the utility's average cost, remain the norm in most countries (Rothman, 2000). Therefore alternative approaches have been used to calculate the hydropower rent.

Bernard et al. (1982) was the first study to estimate hydro rent in Canada. Their purpose was to develop a hypothetical tax base analogous to the tax bases calculated for other natural resources. Therefore, their approach involved estimating "the cost savings or rent arising from the use of a site or deposit compared to the costs of inferior ways of satisfying demand." More specifically, rents were measured as the value of the electricity derived from the hydro site (measured as alternative-method cost) minus all long-run and short-run costs to produce the electricity discounted to a present value.

Zuker and Jenkins (1984) rejected the method used by Bernard et al. (1982) for calculating the hydropower rent as the incremental cost of building new thermal plants to replace hydropower generation (while considering the rest of the system unchanged) includes some costs associated with current system inefficiencies. Instead, Zuker and Jenkins (1984) calculated the rent as the difference between total costs of the current system with hydropower and a hypothetical optimal all-thermal power generation system using a simplified electricity expansion planning model (Shrestha and Abeygunawardana, 2009).

Thus, the two first Canadian studies have calculated the rent, using the difference between the production costs of hydropower plants on a given output and the costs of fossil fuel based power plants for the same output, in order to substitute all the hydropower production. Both studies had to make assumptions on the unit costs of electricity generation given that hydropower was unavailable. The reference electricity prices were estimated using the most effective combination of technologies available at the time of the studies to satisfy the observed load curve, given that hydropower was unavailable. In Gillen and Wen (2000) the financial data of Ontario Hydro were used in order to estimate the potential tax revenues based on the economic rent of the plants and to assess the impact of such a rent taxation. This second approach uses the electricity price as agreed in long-term import/ export contracts. The results of the rent calculation are shown in Table 1.

Given that the long-run marginal cost of electricity generation from sources other than the existing plant is rather uncertain, Amundsen and Tjøtta (1993) considered scenarios of back-stop prices to estimate the long-run rent of hydropower generation in Norway. In this analysis the rent of seven producer regions was measured considering the precipitation variability between Norwegian sites. The authors differentiate between the short-run and the long-run rent. Because of the uncertainties in regard to long-term electricity price forecasts, two scenarios have been calculated: one high backstop price scenario and a low-price scenario. Under such conditions, important rents arise for the Norwegian electricity sector (Table 1).

In comparison to the studies presented above, Banfi et al. (2005) calculate the production costs of the hydropower plants more precisely, because of the detailed data set on the firm level that they had at their disposal. Similar to these studies, the objective of that paper was to carry out an estimation of the total hydropower rent potentially generated in Switzerland by assuming a competitive European and Swiss electricity market. To achieve this goal, the authors calculated the hydropower rent for four different categories of hydropower producers: (i) run-of- river plants of head below 25 m; (ii) run-of-river plants of head above 25 m; (iii) storage plants with pumps and (iv) storage plants without pumps. The paper shows that the hypothetical total rent potentially generated by the Swiss hydropower sectors given assumptions on prices and production, amounts on average to 650 million €/year. The paper also demonstrates that the economic rent varies significantly between the different production technologies. The run-of-river plants account for only 28% of the potential total average rent, whereas the storage plants generate the remaining 72%. Finally, it can be illustrated that a variation in the hypothetical prices, for instance induced by internalization policies, determines significant changes in the level of economic rent potentially generated by the hydropower sector (Banfi et al., 2005).

Considering that the hydropower rent is site specific by nature and thus going along with Banfi et al. (2005)., Shrestha and Abeygunawardana (2009) argue that it is more appropriate to estimate the rent specific to individual hydropower projects rather than the rent of the entire hydropower system. Following the argument of Zuker and Jenkins (1984) for an "ideal" approach, in their study they calculate the economic rent of a hydropower plant (or project) by determining the least-cost power development plans with and without the hydropower plant, whose rent is to be calculated. For that purpose, they use a long-term power generation planning model.

Shrestha and Abeygunawardana (2009) applied their methodology to estimate the rent of a hydropower project in Nepal in two cases: (i) when the project is developed to supply power only to the domestic market of the country and (ii) when the entire hydropower output of the project is exported. Their analysis shows that the economic rent of a hydropower project would be sensitive to changes in discount rate and load growth in both domestic and export markets. The rent is also found to be sensitive to variations in prices of coal and gas in the export market case. A key finding of the study is that the economic rent of a hydropower project does not have a monotonic variation with a change in either the system load growth rate or hydro energy availability. The study also provides an interesting insight to the policy makers engaged in the formulation of a hydropower rent policy that the economic rent of hydropower need not increase with an increase in the price of an individual fossil fuel used by thermal power plants nor does it need to increase always with fuel price escalation rates.

In their study applied in the case of Lao PDR, Boungnong and Phonekeo (2012) also calculated rent for two types of hydropower projects: domestic demand oriented project and large and export oriented project. They also use the concept of hydro rent as a measure of cost savings achievable by the use of hydro resources over the least cost alternatives. Their results shown in Table 1 suggest that the economic benefit is much lower for predominantly export projects than for predominantly domestic consumption projects. However, the authors point out that the easiest projects to finance are probably those with high exports and hence low regional economic value.

Presented as the first attempt to estimate the hydroelectricity rent in Italy the study of Massarutto and Pontoni (2015) show that hydroelectricity production generates the highest rent ever estimated, averaging from 30.3 €/MWh to 82.4 €/MWh. Since operators did not release any information on costs, to estimate both investment costs and operation costs the authors opted for parametric approaches and then compared their values to those published in two surveys conducted by GSE (2010) and IRENA (2012). Concerning the apportionment of that important rent, this paper advocate for the adoption of a resource rent tax, as it would reduce the trade-off between rent-seizing and environmental protection.

Table 1: Comparison of different estimates of the hydropower rent in €/MWh

(Adapted from [Massarutto and Pontoni, 2015])

Author	**Methodology**	**Countries**	**Results (€/MWh)**
Bernard et al. (1982)	Use of the unit cost of electricity production in the absence of the hydropower plants as a proxy for electricity price	Canada	6.8 - 16.4
Zucker and Jenkins (1984)	Same as above but optimization by using a simplified electricity expansion planning model	Canada	27.3
Gilen and Wen (2000)	Same as above but use of the financial data of Ontario Hydro	Canada (Ontario)	25.3
Amundsen and Tjøtta (1993)	Estimation of the long-run rent of	Norway	9.5 - 17

	hydropower generation in consideration of scenarios of back-stop prices		
Banfi et al. (2005)	Calculation of the hydropower rent for run-of- river plants and for storage plants with and without pumps	Switzerland	10.7 - 22.8
Shrestha and Abeygunawardana (2009)	Determination of the least-cost power development plans with and without the hydropower plant	Nepal	6.7 - 23.1
Boungnong and Phonekeo (2012)	Use of the software EVALS to derive two least-cost generation expansion plans: with and without the nominated hydro resource. The difference in the costs of two plans gives the rent of the hydro resource.	Lao PDR	27.3 - 46
Massarutto and Pontoni (2015)	Parametric approach: construction of a dataset on technical and concession-related variables for all hydroelectric plants.	Italy	30.3 - 82.4

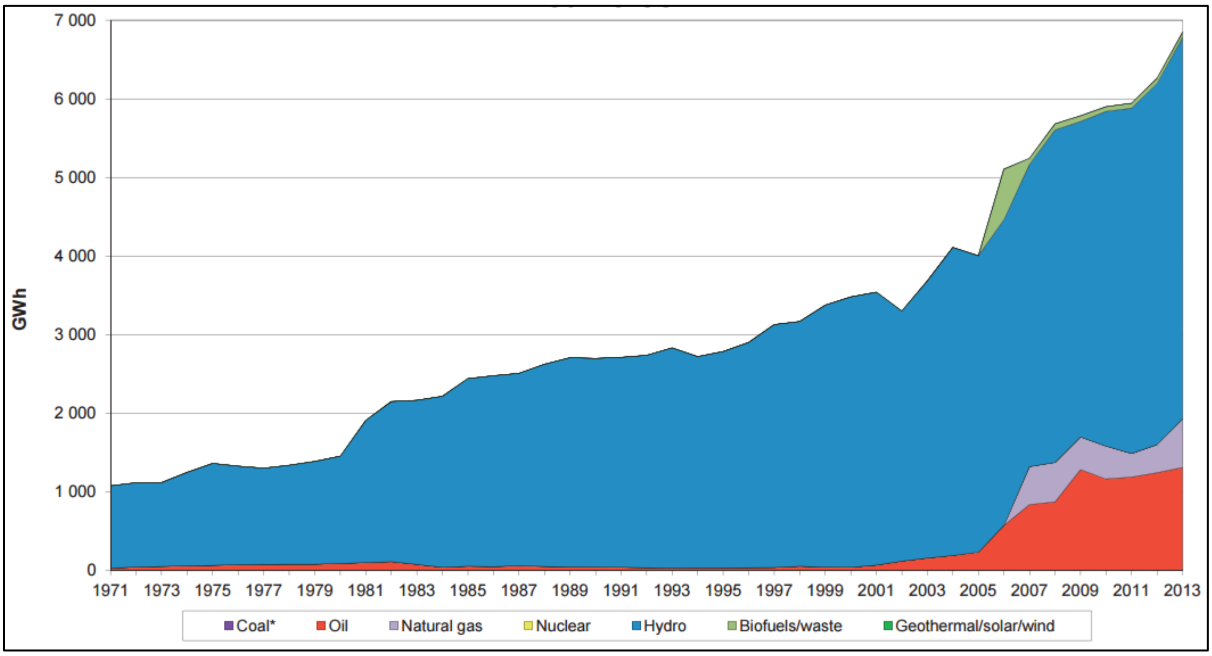
In all the above studies, economic rent is determined either in the case of a perfectly competitive market or by using the electricity price as agreed in long-term import/export contracts or by considering scenarios of back-stop prices. Otherwise, some of the previous studies carried out ex post evaluation of rent specific to individual hydropower project since detailed data were available. In Cameroon, electricity sector is not deregulated and there are no observable competitive electricity prices that could be used to calculate the hydropower rent. Furthermore, the data are not easily available but in this present study, while using a rigorous methodology our purpose is to estimate an ex ante rent of the entire hydropower system.

3. The power sector in Cameroon

3.1 – Overview of the situation

According to the International Energy Agency (Figure 2) Cameroon's total electricity production was estimated at 6849 GWh in 2013 and was mostly based on hydropower (71%). Per capita electricity consumption (0.28 MWh/capita) was very low in comparison with the African average (0.58 MWh/capita) and very far away from the average of the OECD countries (8.07 MWh/capita).

Figure 2: Cameroonian's electricity generation by fuel from 1971 to 2013



Source: International Energy Agency 2016 (Energy Balance of Cameroon)

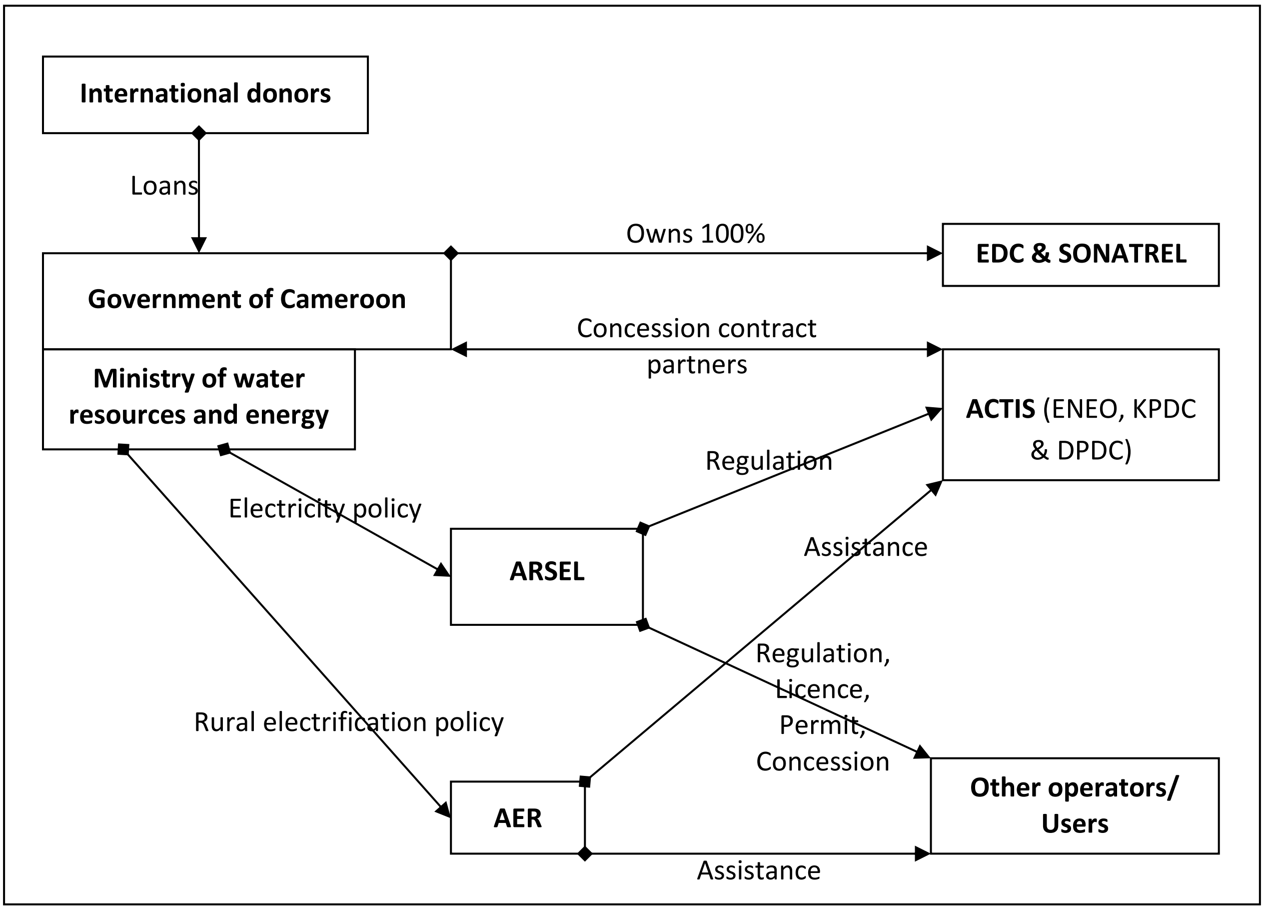
In Cameroon, the supply of public electricity service was provided until 2001 by a wholly integrated electricity company, Sonel (Société Nationale d'Electricité du Cameroun), a monopolistic structure which was responsible for the generation, transmission and distribution of electricity throughout the country. The liberalization of the sector is established by the 1998 electricity law which set a new electricity regulatory framework, where competition principles and private involvement could be developed under the supervision of the Electricity Sector Regulatory Agency (ARSEL). The Electricity Administration, within the Ministry of Water and Energy, defines the country's electricity policy and writes the concession contracts (article 40). This policy is implemented by ARSEL, which also monitors the enforcement of the concession contracts, issuing penalties and fees if necessary (article 40, §6 to 11). Tariffs are set in the concession contracts and are renegotiated every 5 years (article 50). Rural electrification is under the control of another agency, the Rural Electrification Agency (AER).

On July 18, 2001 the Government of Cameroon and AES Corporation signed a concession contract defining the terms, conditions and obligations of AES-Sonel's operations, the new integrated company. On September 12, 2014 AES Sonel was renamed as Eneo Cameroon since the British private equity investment firm, Actis, took over all assets of the American company, AES, in Cameroon's electricity sector[1]. In 2014, Eneo's generation facilities fleet consists of 732 MW of Hydro plants, 301 MW of Thermal Fuel plants and 216 MW of Thermal Gas plants. The transmission network includes 1944.29 km of High-Voltage lines, 15081.48 km of Medium-Voltage lines and 15209.25 km of Low-Voltage lines. The distribution network comprises 11450 km lines of 5.5 to 33 KV and 11158 km lines of 220 to 380 KV (www.eneocameroon.cm visited on June 16, 2016).

Another important player in the electricity sector in Cameroon is EDC (Electricity Development Corporation), a state-owned company, created in November 2006 in order to manage public assets and promote investment in the sector. On October 8, 2015 another state-owned company, la Société Nationale de Transport de l'Electricité (Sonatrel), was created with the responsibility of ensuring the electricity transmission and the management of the transmission network, on behalf of the State. But its actual implementation is still awaited…

Figure 3: Institutional Players in the Cameroonian Electricity Sector

(Adapted from [Fondja, 2012])



[1] Since June 2014, KPDC (Kribi Power Development Company) and DPDC (Dibamba Power Development Company) are the ownership of Globeleq, a wholly-owned Actis company.

3.2 – Future prospects

Cameroon is aiming to become an emerging country by 2035 and to overcome this challenge, the Government has prepared in 2006 a 2030 Electricity Sector Development Plan (PDSE-2030). Due to the non achievement of the objectives targeted by the "National Strategy of Poverty Reduction", launched in 2003 and on which was notably based the former study PDSE-2030, the authorities formulated, in 2009, first a comprehensive socio-economic development vision for the short, medium and long terms, called "Cameroon 2035 Vision", then the "Strategy of Growth and Employment" that focused on the 2010 - 2020 decade, while targeting objectives that are globally aligned to those of "Cameroon 2035 Vision". Both strategies targeted the following objectives, among others: (i) the development of the energy sector in general and that of the electricity in particular, as a prerequisite notably to the implementation of new major and energy-intensive projects, pertaining, in particular, to the industrial and mining sectors, and (ii) the stimulation of the Cameroonian exportations, particularly those of energy to the countries of the Central African region (STUDI International, 2014).

Cameroon has had a decade of strong economic performance, with GDP growing at an average of four percent per year. It reached 5.8% in 2015, compared with 5.9% in 2014 (INS, 2016). But the lack of energy, mainly electrical energy (and particularly in the rural areas) remains the major bottleneck for further economic development. Indeed, many studies have confirmed the intuition that an economic policy aimed at improving energy supply will necessarily have a positive impact on economic growth. One of our previous study found that every percentage increase in oil products consumption increases economic growth by around 1.1 per cent in Cameroon (Fondja, 2013).

Electricity demand continued to witness a robust growth of about 7.5% for the public sector. This trend is essentially due to production in the industrial sector as well as industries in the metallurgy and cement branch and to the increase in the number of connections. Table 2 shows the estimation made by the Consultancy firm "STUDI International" of the overall national demand to be met by the electricity generation. To cope with the growth of electricity demand and in order to achieve the goal of positioning the country as a potential supplier of energy in the Central African Power Pool (PEAC), Cameroon is envisaging to further develop hydropower, not only for its environmental virtues but also because of its wide availability. According to the authorities, the country possesses the second greatest hydroelectric potential in Africa, with an estimated 20 GW, following the Democratic Republic of Congo. However, only less than four percent of this potential is currently realized. Thus, an ex ante calculation of hydropower rent is of interest to policy-makers, lenders and private investors.

Table 2: Overall national demand to be met by the electricity generation

Year	2012	2013	2014	2015	2020	2025	2030	2035
Overall Demand	**Low Scenario**							
Peak (MW) **Energy (GWh/year)**	969 5,315	1,001 5,501	1,030 5,685	1,061 5,877	1,255 7,105	1,473 8,542	1,724 10,246	2,001 12,196
	Median Scenario without Energy management Program							
Peak (MW) **Energy (GWh/year)**	974 5,395	1,046 5,824	1,094 6,109	1,201 6,721	1,803 10,509	2,474 14,921	3,318 20,525	3,906 24,413
	Median Scenario with Energy management Program							
Peak (MW) **Energy (GWh/year)**	974 5,395	1,041 5,804	1,084 6,067	1,186 6,654	1,763 10,254	2,409 14,363	3,228 19,458	3,791 22,666
	High Scenario – All future major projects included – without Energy management Program							
Peak (MW) **Energy (GWh/year)**	974 5,400	1,048 5,832	1,096 6,125	1,206 6,749	2,784 17,375	4,350 27,825	6,178 39,814	7,649 48,906
	High Scenario – All future major projects included – with Energy management Program							
Peak (MW) **Energy (GWh/year)**	974 5,400	1,043 5,812	1,086 6,083	1,191 6,682	2,744 17,106	4,285 27,216	6,088 38,624	7,534 49,910
	High Scenario – Without RTA Project[2] (without taking into account Energy Program)							
Peak (MW) **Energy (GWh/year)**	974 5,400	1,048 5,832	1,096 6,125	1,206 6,749	1,962 11,360	2,867 16,968	4,063 24,332	5,534 33,426

Source: STUDI International (2014)

[2] The two projects relating to ALUCAM factory, previously planned in the locality of EDEA, and having been placed on hold by Rio Tinto Alcan (RTA) until an unidentified date.

4. Methodology and rent evaluation

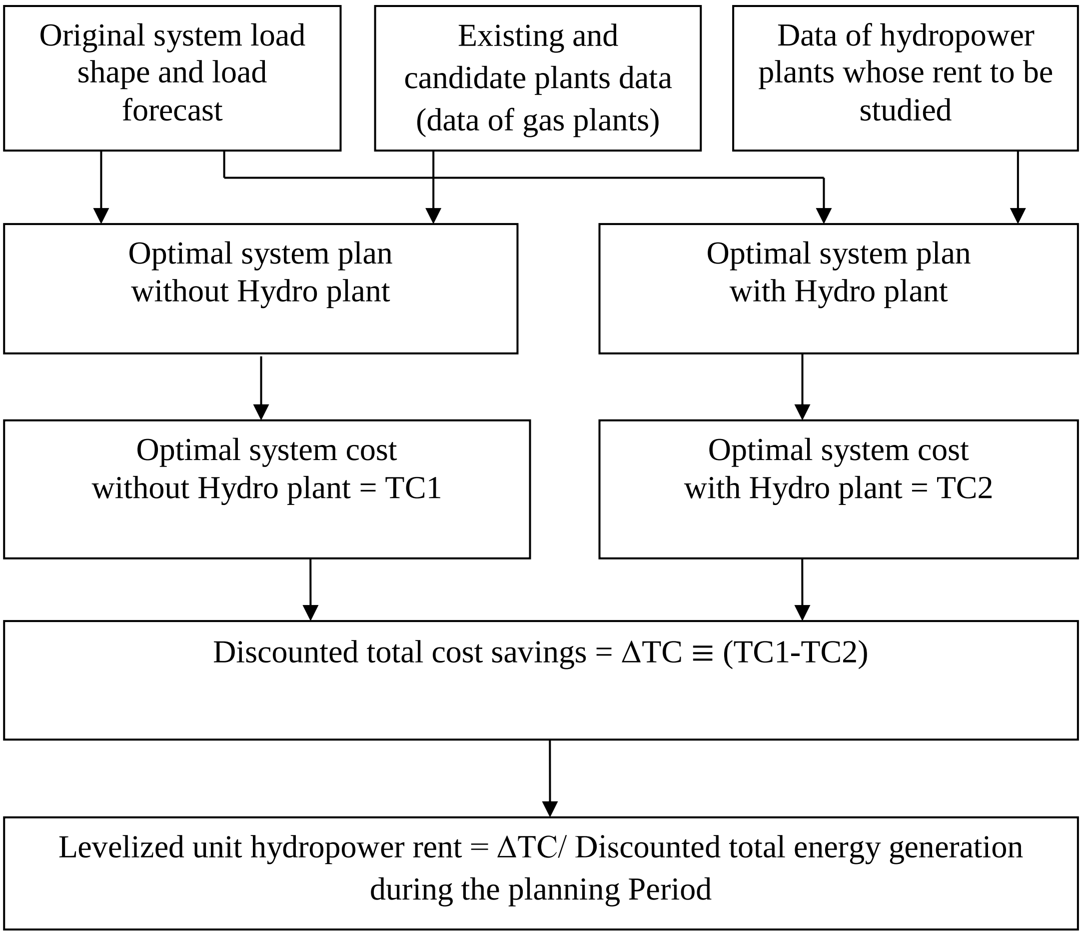
4.1 – Methodology to calculate hydropower rent

According to Zuker and Jenkins (1984), an ideal approach to estimate the economic rent from hydropower production should be based on the difference in cost of the least-cost systems both with and without hydro plant. Following this argument, in this study we evaluate the hydroelectric rent for the entire hydropower system of the Cameroon as the difference between optimized total costs of two hypothetical systems: one with hydropower and the other without hydropower (and thus using gas plants as the substitutes since it is the most likely alternative). The planning period (when the rent is generated) is 2013-2035 and the two scenarios take into account the already installed capacities in 2013.

The flow chart of the methodology is presented in Figure 4 (Shrestha and Abeygunawardana, 2009). The total discounted economic rent (TER) of the hydropower system would be the savings in total cost of power generation (ΔTC) in the presence of low cost hydro resource.

Figure 4: Flowchart of the methodology to calculate hydro rent

(Adapted from [Shrestha and Abeygunawardana, 2009])



Thus, $\mathrm{TER} = \Delta\mathrm{TC} \equiv (\mathrm{TC}_1 - \mathrm{TC}_2)$

The levelized unit economic rent (LER) of the hydropower project can be calculated as

$$\mathrm{TER} = \Delta\mathrm{TC} = \sum_{t=0}^{21} \left(\frac{LER * E_t}{(1+r)^t}\right) \tag{1}$$

Where r is the discount rate; E_t is the electricity generated in year t (t=0 corresponds to 2013 and t=21 corresponds to 2035)

Rearranging Equation (1), we get

$$\mathrm{LER} = {}^{\Delta\mathrm{TC}}\Big/_{\sum_{\mathrm{t}=0}^{21} \frac{E_t}{(1+r)^t}} \tag{2}$$

4.2 – Input data and assumptions

The planning horizon of the present study is 22 years (i.e. from 2013 to 2035). Year 2013 is considered as the base year for the purpose of calculating the costs of generation expansion plans. A discount rate of 10% is considered, which is the rate usually used in the public sector projects in Cameroon.

The software LEAP (Long range Energy Alternatives Planning System) version: 2015.0.19.0 (developed at the Stockholm Environment Institute) was used to determine the optimized total costs of generation expansion plans in order to meet the projected demand. The model is discussed in detail in Appendix A.

4.2.1 – ASSUMPTIONS REGARDING THE CAPACITIES AND ELECTRICITY DEMAND

According to the Table 2, the projected electricity demands in 2035 are 12196 GWh (Low scenario), 24413 GWh (Median scenario without Energy management) and 48906 GWh (High scenario without Energy management). The corresponding peak capacities are 2001 MW, 3906 MW and 7649 MW.

4.2.1.1 – "High" Scenario

It is an optimistic scenario which aims to make Cameroon become an emergent country beyond 2030 and is translated into an annual economic growth of 6.53% on average over the entire duration of the study (STUDI International, 2014).

This scenario assumes, in accordance with the strategic guidelines of the State of Cameroon, the realization of all the major/great planned projects, in particular the industrial and mining ones, expected to be highly energy-consuming, even the most ambitious ones and the heaviest to finance, as well as the energy infrastructure projects, without delays in the endorsed due dates. In terms of interconnection with neighboring countries, the High scenario is also aligned with the strategic ambitions of local authorities for the implementation and strengthening of energy exports from Cameroon, by the specific valorization of hydropower potential. In this context, all the interconnections[3] are taken into account and are supposed to be materialized according to the announced or estimated achievable horizons. Table 3 shows the growth rates of the capacities and the electricity demands from the current situation.

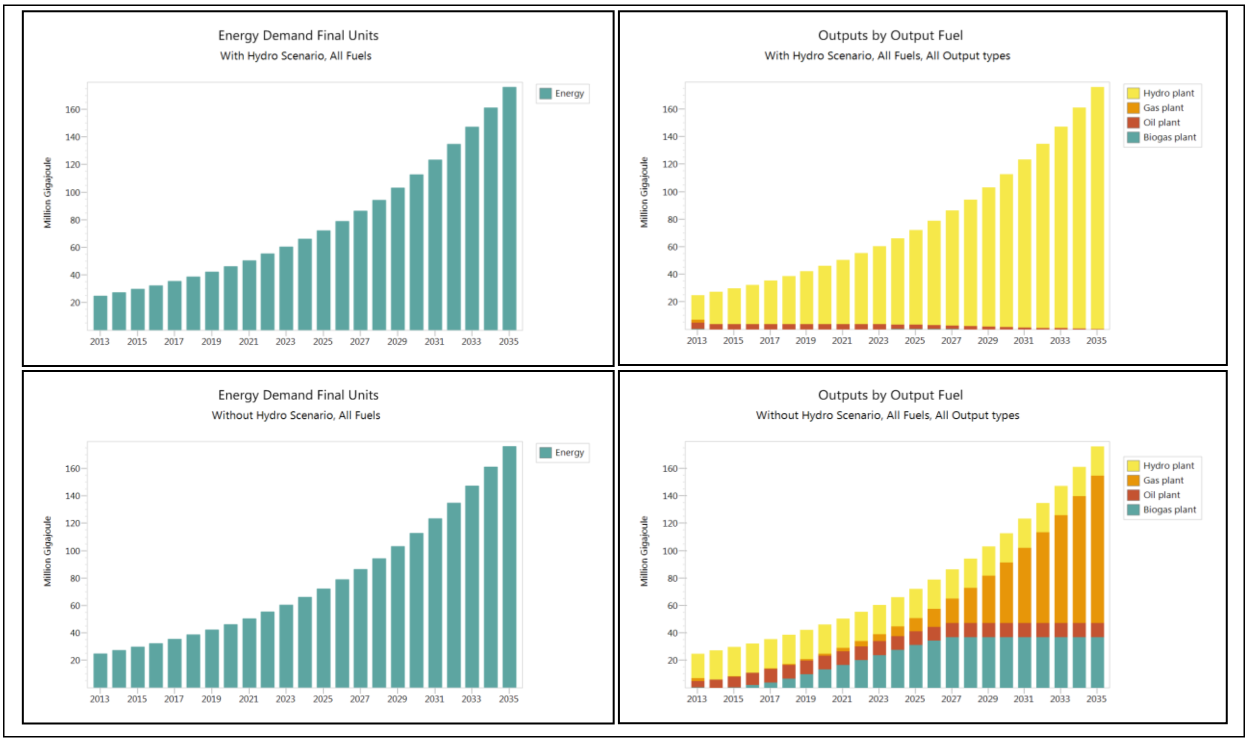
Table 3: Growth rates of the capacities and electricity demand for the High scenario

Year		2013 (current situation)	2035 (High scenario)	Growth rate (with Hydro)	Growth rate (without Hydro)
Electricity demand (GWh)	Hydro	4855	48906	9.35	9.35
	Gas	617			
	Oil	1309			
	Biogas	68			
	Total	6849			
Peak capacities (MW)	Hydro	742	742 (7104)	(10.82)	0
	Gas	216	216 (6578)	0	(16.8)
	Oil	321	321	0	0
	Biogas	8	8	0	0
	Total	1287	7649		

The charts of Figure 5 show the evolution of the electricity demand under the High scenario with and without additional hydro plants.

[3] Namely interconnections with Chad (N'Djamena and 17 border communities) from 2015, with Nigeria (Yola from 2020), via Nigeria and to the West Africa (from 2031), and with the Central African Republic from 2019.

Figure 5: Evolution of the electricity demand for the High scenario with and without additional hydro plants



4.2.1.2 – "Median" Scenario

This is a more conservative scenario. Its hypotheses are aligned with the risk analysis results considering more reservations on the materialization of aimed large-scale projects, particularly those of the energy sector and the intensive energy-consumer projects (industrial and mining in particular). This resulted in an Average Annual Growth Rate of the national real GDP estimated to 6.05% on average over the study period (STUDI International, 2014).

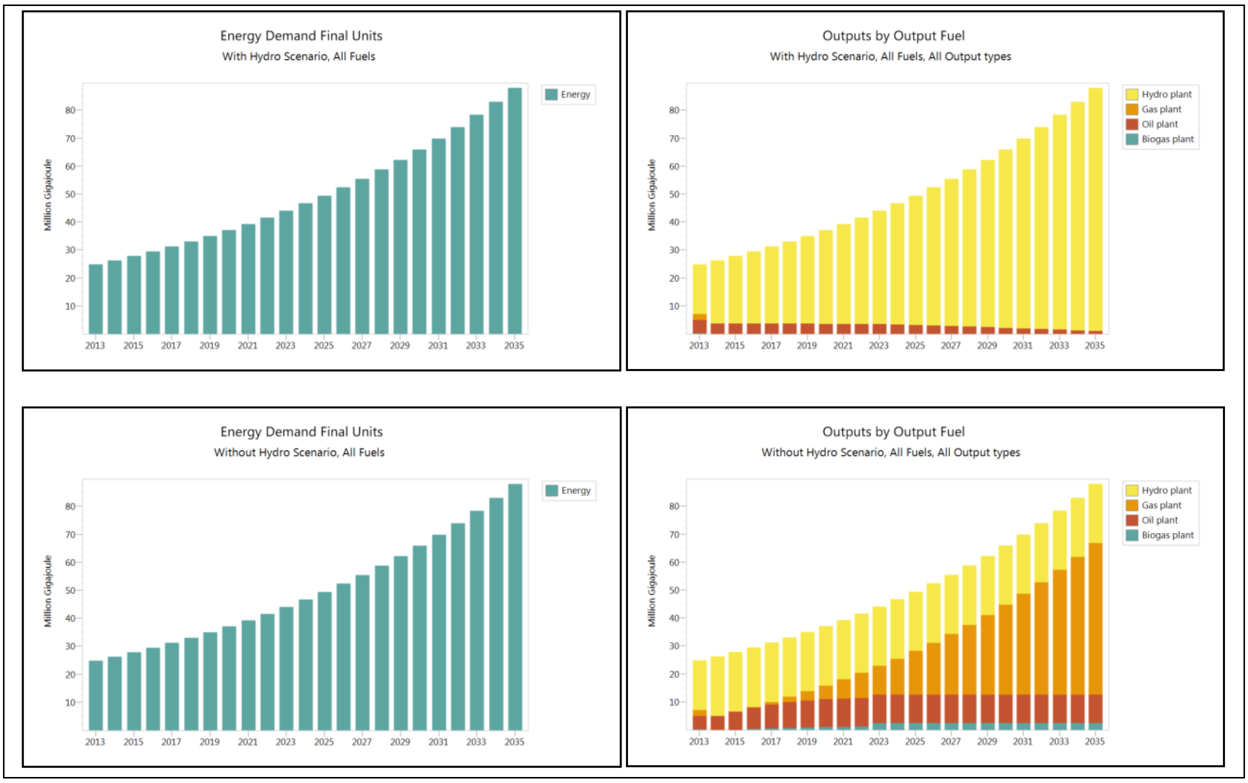
Specifically, this scenario considers the realization of projects that seem the safest, and whose achievement appears as more likely. In terms of interconnections with neighbors, this scenario considers the realization of those appearing as the most pressing, namely the interconnection with N'Djamena in Chad and Yola in Nigeria. Table 4 shows the growth rates of the capacities and the electricity demands from the current situation.

Table 4: Growth rates of the capacities and electricity demand for the Median scenario

	Year	2013 (current situation)	2035 (Median scenario)	Growth rate (with Hydro)	Growth rate (without Hydro)
Electricity demand (GWh)	Hydro	4855	24413	5.95	5.95
	Gas	617			
	Oil	1309			
	Biogas	68			
	Total	6849			
Peak capacities (MW)	Hydro	742	742 (3361)	(7.11)	0
	Gas	216	216 (2835)	0	(12.43)
	Oil	321	321	0	0
	Biogas	8	8	0	0
	Total	1287	3906		

The charts of Figure 6 show the evolution of the electricity demand under the Median scenario with and without additional hydro plants.

Figure 6: Evolution of the electricity demand for the Median scenario with and without additional hydro plants



4.2.1.3 – "Low" Scenario

This is the most pessimistic scenario, assuming in the future less stimulation of the Cameroonian economy and the business climate in the country, which should result in the non-realization of all the future major projects announced. This scenario is based on the underlying assumptions, admitting a continuation of the growth rate of the national real GDP, with a slow and weak trend of improvement that will fade in the long run. The Average Annual Growth Rate of the GDP is thus estimated at 3.81% per annum on average throughout the duration of the study (STUDI International, 2014). Per capita income is expected to grow gradually, but in a more close way to the recent recorded data.

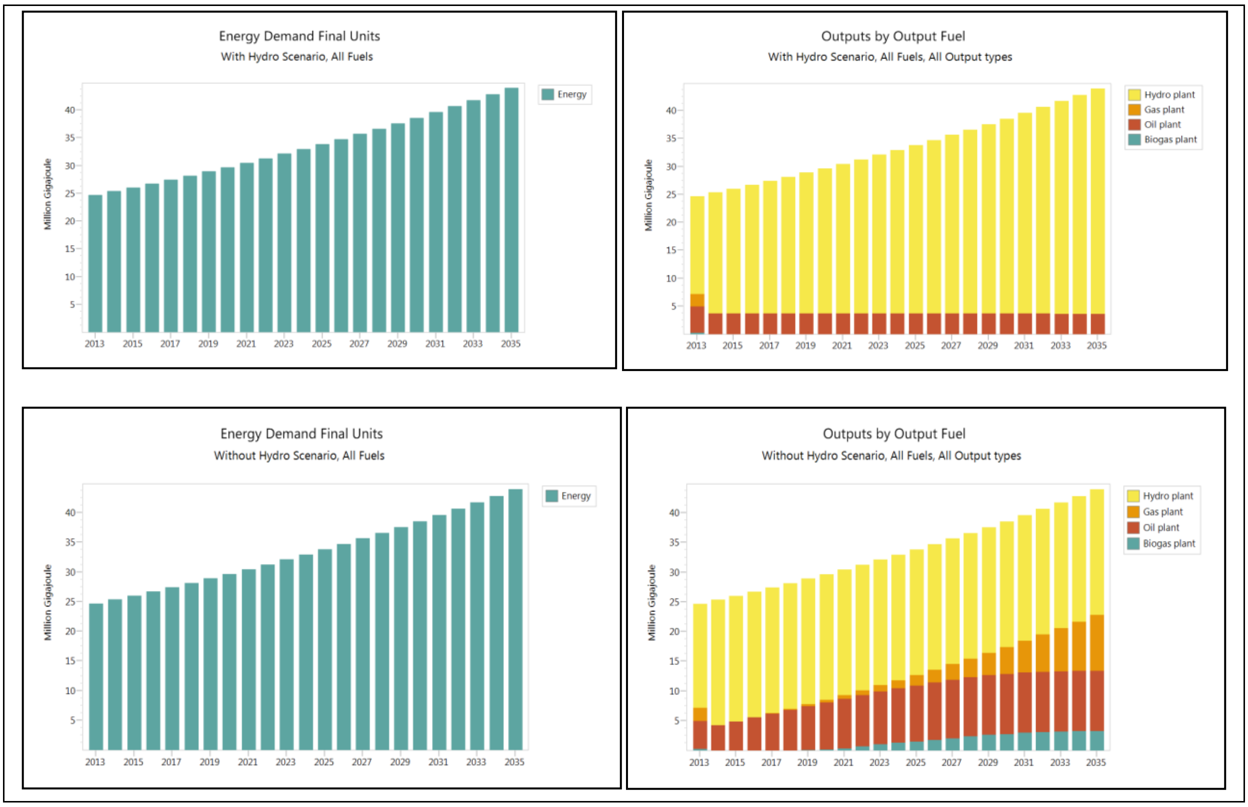
This scenario also assumes that none of the interconnections, subject of conventions or regional projects' ideas, can be realized and that Cameroon will look exclusively to meet the local power demand, throughout the study period. Table 5 shows the growth rates of the capacities and the electricity demands from the current situation.

Table 5: Growth rates of the capacities and electricity demand for the Low scenario

<table>
<tr><th colspan="2">Year</th><th>2013
(current situation)</th><th>2035
(Low scenario)</th><th>Growth rate
(with Hydro)</th><th>Growth rate
(without Hydro)</th></tr>
<tr><td rowspan="5">Electricity demand (GWh)</td><td>Hydro</td><td>4855</td><td rowspan="5">12196</td><td rowspan="5">2.66</td><td rowspan="5">2.66</td></tr>
<tr><td>Gas</td><td>617</td></tr>
<tr><td>Oil</td><td>1309</td></tr>
<tr><td>Biogas</td><td>68</td></tr>
<tr><td>Total</td><td>6849</td></tr>
<tr><td rowspan="5">Peak capacities (MW)</td><td>Hydro</td><td>742</td><td>742 (1456)</td><td>(3.14)</td><td>0</td></tr>
<tr><td>Gas</td><td>216</td><td>216 (930)</td><td>0</td><td>(6.9)</td></tr>
<tr><td>Oil</td><td>321</td><td>321</td><td>0</td><td>0</td></tr>
<tr><td>Biogas</td><td>8</td><td>8</td><td>0</td><td>0</td></tr>
<tr><td>Total</td><td>1287</td><td>2001</td><td></td><td></td></tr>
</table>

The charts of Figure 7 show the evolution of the electricity demand under the Low scenario with and without additional hydro plants.

Figure 7: Evolution of the electricity demand for the Low scenario with and without additional hydro plants



4.2.2 – Data used in the analysis

The fuel costs, the capital costs and the fixed and variable operating and maintenance costs of the various electric generation power plants used in this study are given in the table 6.

Table 6: Estimated costs for electric facilities

Fuel type	Capital (€/kW)	Fixed O&M (€/MW)[d]	Variable O&M (€/MWh)[d]	Fuel costs (€/ton)[d]
Hydropower plant	3000[a]	46	2.22[e]	0
Gas plant	575[b]	12.2	6.1	117
Oil plant	1041[c]	12.2	6.1	742.65[f]
Biogas plant	575	12.2	6.1	117

[a] According to STUDI International (2014) for a hydropower plant below 200 MW

[b] According to NREL (2012) for a Gas Turbine Power Plant of 211 MW

[c] According to ESMAP (2009) for a 300 MW Oil-Fired Power Plant

[d] According to STUDI International (2014) from KPDC and SONARA[4] (Cameroon)

[e] corresponds to the water license fee

[f] corresponds to the weighted average costs of Light Fuel Oil (LFO) and Heavy Fuel Oil (HFO)

[4] The National Refinery Company

5. Results and sensitivity analyses

5.1 – Results

In this study we use the software LEAP as a cost-benefit calculator to determine the optimized total costs of generation expansion plans in order to meet the projected demand. The model is discussed in detail in Appendix A. The fuel costs, the capital costs and the fixed and variable operating and maintenance costs of the different power plants given in the table 6 are specifying into LEAP. The salvage values (or decommissioning costs) for decommissioning processes and the environmental externality values (i.e. pollution damage or abatement costs) are not taken into account since data are not available.

In this research the hydropower rent is calculated for the whole country as the difference between optimized total costs of two hypothetical systems: one with hydropower and the other without hydropower. The savings in total cost with hydro plants ΔTC is the difference between optimized total costs (the sum of all discounted costs and benefits across all years of the study or the Net Present Value) of the scenario with hydropower and the scenario without hydropower.

5.1.1 – "HIGH" SCENARIO

In this high scenario, existing Oil and Biogas power plants are expected to be unchanged. In the case With Hydro, Gas power plants also remain unchanged and only Hydro power plants increase at an annual rate of 10.82 % to reach 7104 MW in 2035. In the case Without Hydro, Hydro power plants also remain unchanged and only Gas power plants grow at an annual rate of 16.8 % to reach 6578 MW in 2035.

Under the above assumptions, the Savings in total cost with hydro plants for the High scenario is ΔTC = 1846.1 M€ (Table B2 in Appendix B shows a screenshot of LEAP calculation). The scenario with hydropower is cheaper than the scenario without hydropower, and even than the scenario of Business as usual (Reference scenario). Indeed, if capital costs are higher for hydropower plants, the operating and fuel costs are lower and make this technology economically better than oil and gas plants.

Energy production in 2013 is E_0 = 6849 GWh and $E_t = E_0 * (1 + 9.35\%)^t$ with t = 1, 3,... 21

According to Equation (2), the levelized unit economic rent (LER) of the hydropower project is

$$\text{LER} = {\Delta\text{TC}}\Big/{\sum_{\text{t}=0}^{21} \frac{E_t}{(1+r)^t}} = {\Delta\text{TC}}\Big/{E_0 \sum_{\text{t}=0}^{21} \frac{(1+0.0935)^t}{(1+0.1)^t}}$$

Thus, $\text{LER} = {1846.1}\big/{6849 * 20.687} = 13.030$

Therefore, the economic rent for the high scenario is $\mathbf{13.030}$ **€/MWh**

5.1.2 – "MEDIAN" SCENARIO

In this median scenario, existing Oil and Biogas power plants are expected to be unchanged. In the case With Hydro, Gas power plants also remain unchanged and only Hydro power plants increase at an annual rate of 7.11 % to reach 3361 MW in 2035. In the case Without Hydro, Hydro power plants also remain unchanged and only Gas power plants grow at an annual rate of 12.43 % to reach 2835 MW in 2035.

Under the above assumptions, the Savings in total cost with hydro plants for the Median scenario is ΔTC = 1770.3 M€ (Table B4 in Appendix B shows a screenshot of LEAP calculation). Here again, the scenario with hydropower is cheaper than the scenario without hydropower, and even than the scenario of Business as usual (Reference scenario). Indeed, if capital costs are higher for hydropower plants, the operating and fuel costs are lower and make this technology economically more attractive than oil and gas plants.

Energy production in 2013 is E_0 = 6849 GWh and $E_t = E_0 * (1 + 5.95\%)^t$ with t = 1, 3,... 21

According to Equation (2), the levelized unit economic rent (LER) of the hydropower project is

$$\text{LER} = \Delta\text{TC} \Big/ \sum_{t=0}^{21} \frac{E_t}{(1+r)^t} = \Delta\text{TC} \Big/ E_0 \sum_{t=0}^{21} \frac{(1+0.0595)^t}{(1+0.1)^t}$$

Thus, $\text{LER} = 1770.3 \big/ 6849 * 15.261 = 16.937$

Therefore, the economic rent for the median scenario is $\mathbf{16.937\ €/MWh}$

5.1.3 – "LOW" SCENARIO

In this low scenario, existing Oil and Biogas power plants are expected to be unchanged. In the case With Hydro, Gas power plants also remain unchanged and only Hydro power plants increase at an annual rate of 3.14 % to reach 1456 MW in 2035. In the case Without Hydro, Hydro power plants also remain unchanged and only Gas power plants grow at an annual rate of 6.9 % to reach 930 MW in 2035.

Under the above assumptions, the Savings in total cost with hydro plants for the Median scenario is ΔTC = 1227.3 M€ (Table B6 in Appendix B shows a screenshot of LEAP calculation). Once again, the scenario with hydropower is cheaper than the scenario without hydropower, and even than the scenario of Business as usual (Reference scenario). Indeed, if capital costs are higher for hydropower plants, the operating and fuel costs are lower and make this technology economically more cost-effective than oil and gas plants.

Energy production in 2013 is E_0 = 6849 GWh and $E_t = E_0 * (1 + 2.66\%)^t$ with t = 1, 3,... 21

According to Equation (2), the levelized unit economic rent (LER) of the hydropower project is

$$\text{LER} = {\Delta\text{TC}}\Big/{\sum_{\text{t}=0}^{21} \frac{E_t}{(1+r)^t}} = {\Delta\text{TC}}\Big/{E_0 \sum_{\text{t}=0}^{21} \frac{(1+0.0266)^t}{(1+0.1)^t}}$$

Thus, $\text{LER} = {1227.3}\big/{6849 * 11.706} = 15.308$

Therefore, the economic rent for the low scenario is $\mathbf{15.308\ €/MWh}$. According to our definition of the economic rent this result imply that producing 1 MWh of electricity from Hydropower plants rather than Gas power plants gives rise to a significant surplus of 15.308 euros to owners.

5.2 – Sensitivity analyses

5.2.1 – SENSITIVITY OF HYDROPOWER RENT TO VARIATION IN DISCOUNT RATE

The following table 7 presents the changes in hydropower rent when the discount rate is decreased from 10% to 8% and when it is increased to 12%.

Table 7: Sensitivity of hydropower rent to variation in discount rate

Hydropower rent (in Euro/MWh)		**Low Scenario**	**Median Scenario**	**High Scenario**
Discount rates	8%	16.247	17.185	12.665
	10% (Base case)	**15.308**	**16.937**	**13.030**
	12%	14.406	16.642	13.326

The findings of the previous analysis show that the economic rent of a hydropower project would be sensitive to changes in discount rate. For a range of discount rate varying from 8% to 12%, changes in the rent are relatively small and not necessarily in the same direction. Thus, an increase in the discount rate leads to a decrease in hydro rent for Low and Small Scenarios, while it results in an increase in rent for the High Scenario. One explication is that in the high scenario where capacities are growing very fast, with high discount rate the Savings in total cost are lower but still higher than the total discounted energy generation.

5.2.2 – SENSITIVITY OF HYDROPOWER RENT TO VARIATION IN CAPACITY COSTS

The following table 8 shows the effects of variation in capacity costs when the discount rate is 10%.

Table 8: Sensitivity of hydropower rent to variation in capacity costs

Hydropower rent (in Euro/MWh)		**Low Scenario**	**Median Scenario**	**High Scenario**
Capital costs (Percentage of increase, with 10% in discount rate)	-1%	15.697	17.93	14.664
	+ 1%	14.876	15.83	11.192
	+ 3%	13.877	13.215	6.794

The results of table 8 confirm that the rent of a hydropower project depends on a number of parameters of the electricity industry, and first of all on capacities costs. The rent definitely decreases with an increase in capacity costs.

5.2.3 – SENSITIVITY OF HYDROPOWER RENT TO VARIATION IN FUEL COSTS OF OIL AND GAS

The following table 9 presents the changes in hydropower rent in case of the variation of fuel costs and when the discount rate is 10%.

Table 9: Sensitivity of hydropower rent to variation in fuel costs of oil and gas

Hydropower rent (in Euro/MWh)		**Low Scenario**	**Median Scenario**	**High Scenario**
Fuel costs of oil and gas (Percentage of increase, with 10% in discount rate)	-1%	13.159	13.986	11.26
	+ 1%	17.756	20.307	15.096
	+ 3%	23.737	28.575	20.329

According to these results, and as might be expected, the hydropower rent change monotonically with change in prices of oil and gas.

6. Conclusions and possible policy implications of this study

The aim of this paper is to estimate the economic rent generated in the Cameroonian hydropower sector. To this end, the methodology used is to calculate the rent as the difference between optimized total costs of two hypothetical systems: one with hydropower and the other without hydropower. Of course, our results depend on important assumptions with regard to CAPEX, OPEX and electricity demand since the rent of a hydropower project depends on a number of parameters of the electricity industry. For the most likely Median scenario concerning the future demand trends, our calculation gives a value of 16.937 Euro/MWh of hydropower rent.

According to our definition of the economic rent this result imply that producing 1 MWh of electricity from Hydropower plants rather than Gas power plants gives rise to a significant surplus of 16.937 euros to owners. This rent is in the range of values found by Amundsen and Tjøtta (1993), Banfi et al. (2005) and Shrestha and Abeygunawardana (2009) for Norway, Switzerland and Nepal respectively (Cf. Table 1). This value does not include well-known negative externalities of thermal power plants and other benefits of the construction of hydropower plants such as irrigation water and flood control. Hence, it is enough to encourage Government, private companies and investors to develop the hydropower sector.

Notwithstanding the methodologies used for its estimation, it is possible to say that hydropower generates a noteworthy rent. The ex ante calculation of hydropower rent is of interest to policy makers in countries like Cameroon, which have large number of projects yet to be developed. But, it should be noted that the estimations of the potential hydropower rent illustrated in this study are based on important assumptions. Therefore, our results should be considered as a first approximation and used with caution, since they do not reflect actual values realized or faced in the hydropower sector today. Future lines of research should go towards a more precise estimation of the hydro rent in Cameroon, by using hourly production data and real costs.

7. Acknowledgements

The authors would like to thank anonymous reviewers and the Editor of the journal for many valuable comments. However, the authors only are responsible for any remaining errors in the paper. The first author would like to express his gratitude for Jacques NTOGUE of Paris Dauphine University and for all the members of the Institute of Energy and Sustainable Development of De Montfort University (United Kingdom) for their warm welcome.

8. Appendix

8.1 – Appendix A: The generation expansion planning model

In this study the hydropower rent is calculated for the whole country as the difference between optimized total costs of two hypothetical systems: one with hydropower and the other without hydropower. The software LEAP was used to determine the optimized total costs of generation expansion plans in order to meet the projected demand.

In calculating the optimal system LEAP takes into account all of the relevant costs and benefits incurred in the system including:

- The capital costs for building new processes.
- The salvage values for decommissioning processes
- The fixed and variable operating and maintenance costs
- The fuel costs
- The environmental externality values.

The output of the model will describe the desired types of generating plants to be added, their capacity, the years when the new capacities should be added during the planning period, and the levels of electricity generation by each of the new and existing generating plants during each year in the planning period in order to meet the projected future electricity demand at the minimum cost.

The objective function is to, for each year (y) and technology (t) minimize the costs of the system. Algebraically, the objective function can be expressed as

Minimize

$$\sum_{y}\sum_{t}\left(DiscOperatingCost_{y,t} + DiscCapitalInvestment_{y,t} - SalvageValue_{y,t}\right)$$

Where

(1) $DiscOperatingCost_{y,t}$ is the discounted total operating costs per year for each technology and is calculated as :

$$DiscOperatingCost_{y,t} = \left(TotCapAnn_{y,t} * FixedCost_{y,t} + \sum_{l}\left(Activity_{y,l,t} * \text{VariableCost}_{y,t} * YearSplit_{y,l}\right)\right) * DiscountFactor_{y,t}$$

$TotCapAnn_{y,t}$: This variable gives the total capacity available by technology for each year

$FixedCost_{y,t}$: The fixed cost, also a function of technology as well as the model year, is the cost per unit of capital stock (or installed capacity) of a particular technology.

$\mathrm{VariableCost}_{y,t}$: The variable cost is defined for each technology in each year and is the cost per unit of activity of that technology

$Activity_{y,l,t}$: This variable represents the "activity" of the technology. Its unit is in terms of power – of energy out per year. Where the energy out, is related by an output to activity ratio. (Conversely the energy used is related to the activity by an input to activity ratio). Activity is calculated for each technology, for each year and for each time slice (l).

$YearSplit_{y,l}$: The fraction of the year accounted for in each load region

(2) $DiscCapitalInvestment_{y,t}$ is the annual discounted capital investment for each technology and is calculated as :

$$DiscCapitalInvesment_{y,t} = CapitalCost_{y,t} * NewCap_{y,t} * DiscountFactor_{y,t}$$

$CapitalCost_{y,t}$: The capital cost of each technology is given as a function of the technology as well as the year in which the technology was invested.

$NewCap_{y,t}$: This is new investment in capacity by the model year in which the investment was made, for each technology.

(3) $SalvageValue_{y,t}$ is the value of each technology remaining at the end of the modeling period and its expression is :

$$SalvageValue_{y,t} = CapitalCost_{y,t} * NewCap_{y,t} * SalvageFactor_{y,t}$$

$SalvageFactor_{y,t}$: This is the (discounted) salvage value of a technology at the end of the modeling period, represented as a fraction of the initial per unit capital cost. It is determined for each model year as well as each technology. It is calculated by estimating the depreciated value of the technology at end of the modeling period.

The constraints are:

(1) Fuel Production Constraints: Fuel production during each time slice (l) and year (y) must be greater than or equal to its use (consumption) by technologies plus any exogenous demand for that fuel (f). That is :

$$Production_{y,l,f} \geq Demand_{y,l,f} + Consumption_{y,l,f}$$

Where

$$Production_{y,l,f} = \sum_{t} (Activity_{y,l,t} * OtptActvtyRatio_{y,t,f} * YearSplit_{y,l}$$

And

$$Consumption_{y,l,f} = \sum_{t} (Activity_{y,l,t} * InptActvtyRatio_{y,t,f} * YearSplit_{y,l}$$

$OtptActvtyRatio_{y,t,f}$: The output activity ratio, gives the output of fuel as a ratio to the activity of the technology. It is defined by year (as the technology could degrade), by technology, by time slice and for the fuel which is produced.

$InptActvtyRatio_{y,t,f}$: The input activity ratio, gives the input (use) of fuel as a ratio to the activity of the technology. It is defined by year (as the technology could degrade), by technology, by time slice and for the fuel which is used.

(2) Capacity constraints: The capacity of each technology must be greater than its activity for each load region. That is

$$Activity_{y,l,t} \leq TotCapAnn_{y,t} * CapacityFactor_{y,t} * OneMatrixLR_{l}$$

$CapacityFactor_{y,t}$: This is defined for each year (y) and each technology (t). It is used to convert annual capacity to available capacity for each time slice (l).

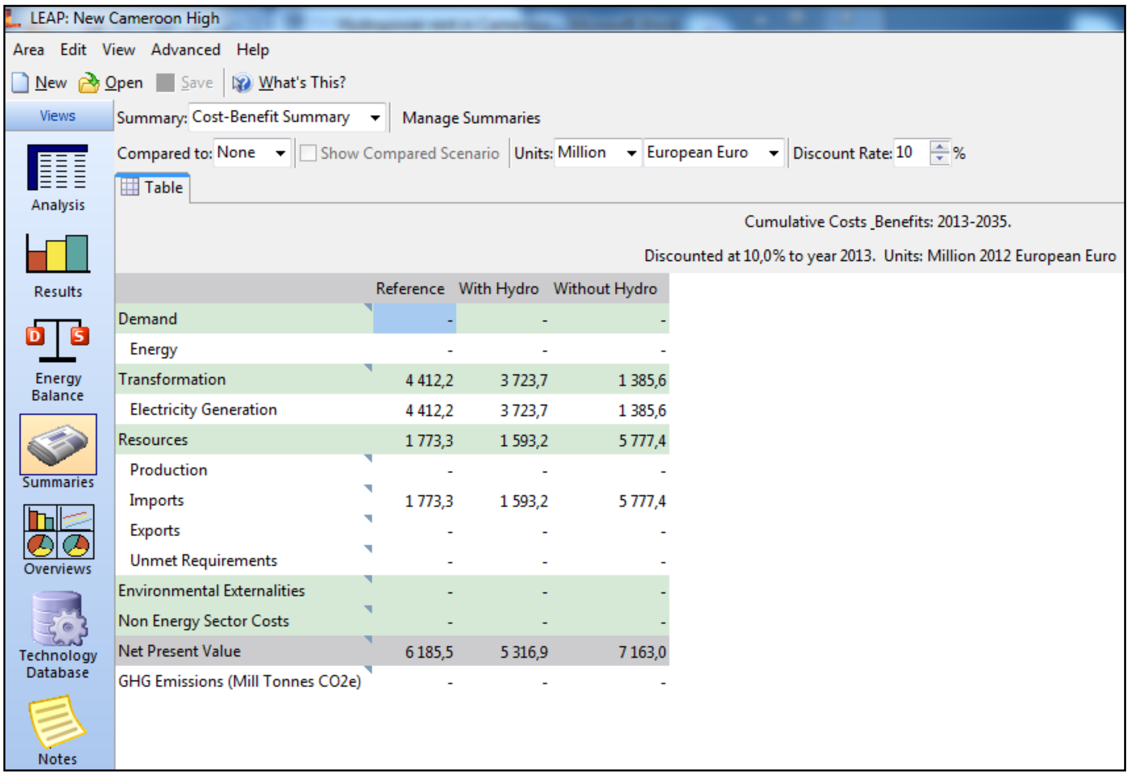
(3) Activity constraints: The activity of each technology is limited by its annual availability. That is

$$\sum_{l} \left(Activity_{y,l,t} * YearSplit_{y,l}\right) \leq TotCapAnn_{y,t} * AvailabilityFactor_{y,t} * CapacityFactor_{y,t}$$

$AvailabilityFactor_{y,t}$: This is defined for each year and each technology. It is used to simulate "planned outages" and indicates the maximum the technology may run for the whole year.

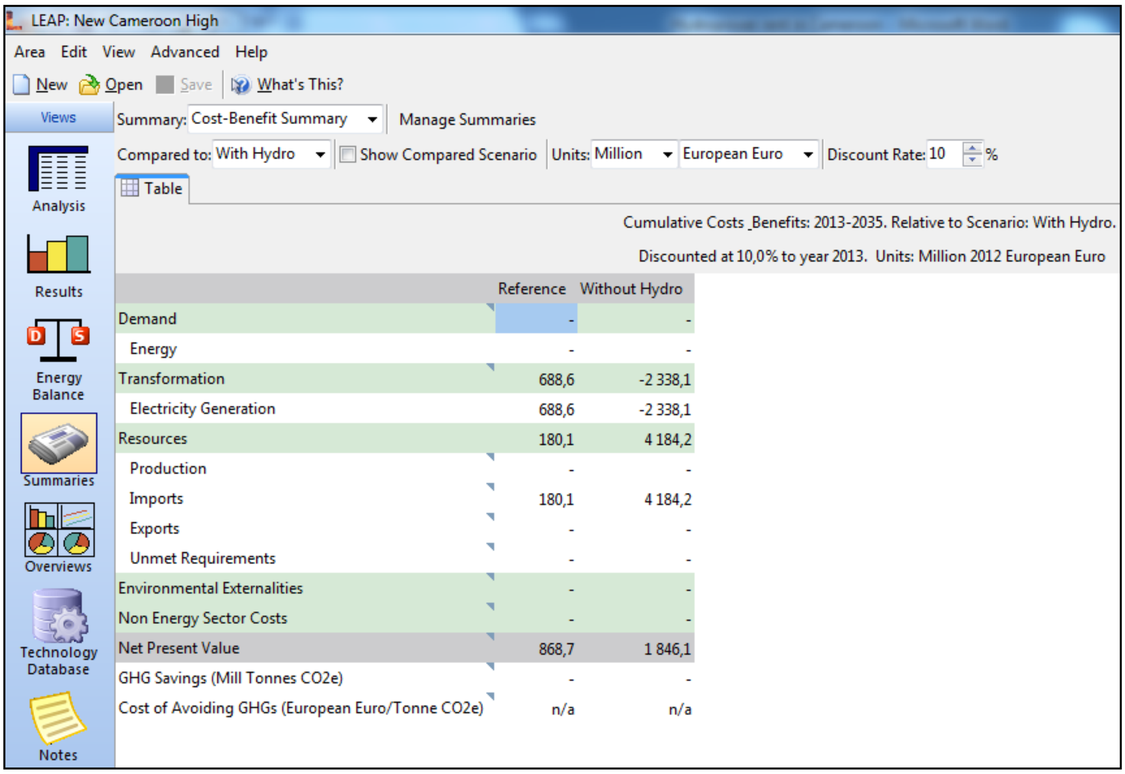
8.2 – Appendix B: Screenshots of LEAP calculations

Table B1: Screenshot of the result of LEAP calculation for the High scenario



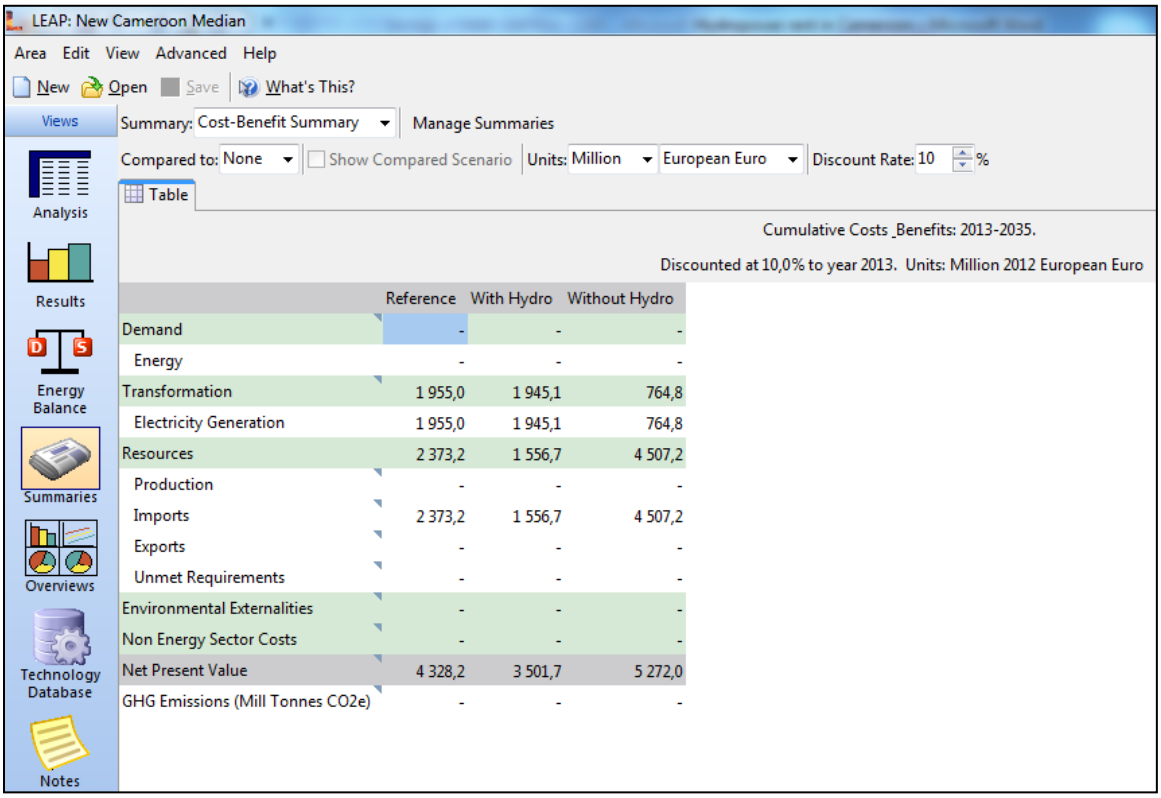
	Reference	With Hydro	Without Hydro
Demand	-	-	-
Energy	-	-	-
Transformation	4 412,2	3 723,7	1 385,6
Electricity Generation	4 412,2	3 723,7	1 385,6
Resources	1 773,3	1 593,2	5 777,4
Production	-	-	-
Imports	1 773,3	1 593,2	5 777,4
Exports	-	-	-
Unmet Requirements	-	-	-
Environmental Externalities	-	-	-
Non Energy Sector Costs	-	-	-
Net Present Value	6 185,5	5 316,9	7 163,0
GHG Emissions (Mill Tonnes CO2e)	-	-	-

Table B2: Screenshot of the result of LEAP calculation for the High scenario – The savings in total cost with hydro plants is ΔTC = 1846.1 M€



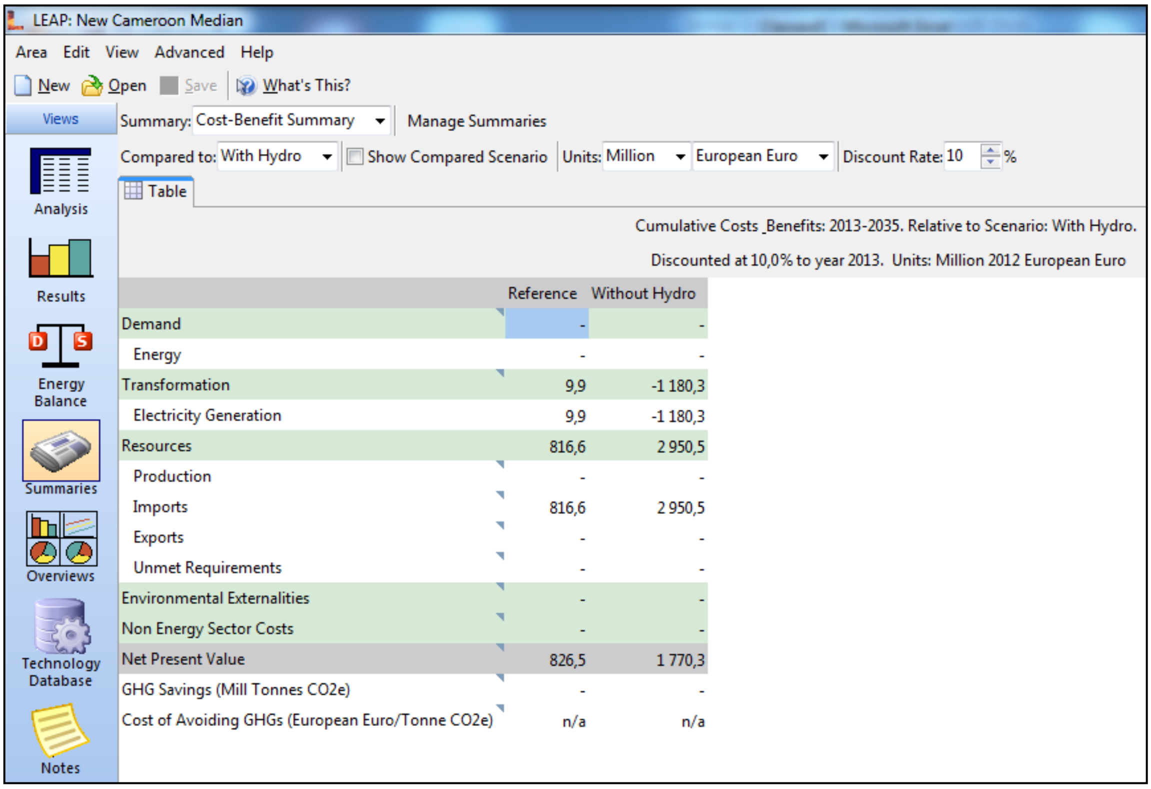
	Reference	Without Hydro
Demand	-	-
Energy	-	-
Transformation	688,6	-2 338,1
Electricity Generation	688,6	-2 338,1
Resources	180,1	4 184,2
Production	-	-
Imports	180,1	4 184,2
Exports	-	-
Unmet Requirements	-	-
Environmental Externalities	-	-
Non Energy Sector Costs	-	-
Net Present Value	868,7	1 846,1
GHG Savings (Mill Tonnes CO2e)	-	-
Cost of Avoiding GHGs (European Euro/Tonne CO2e)	n/a	n/a

Table B3: Screenshot of the result of LEAP calculation for the Median scenario



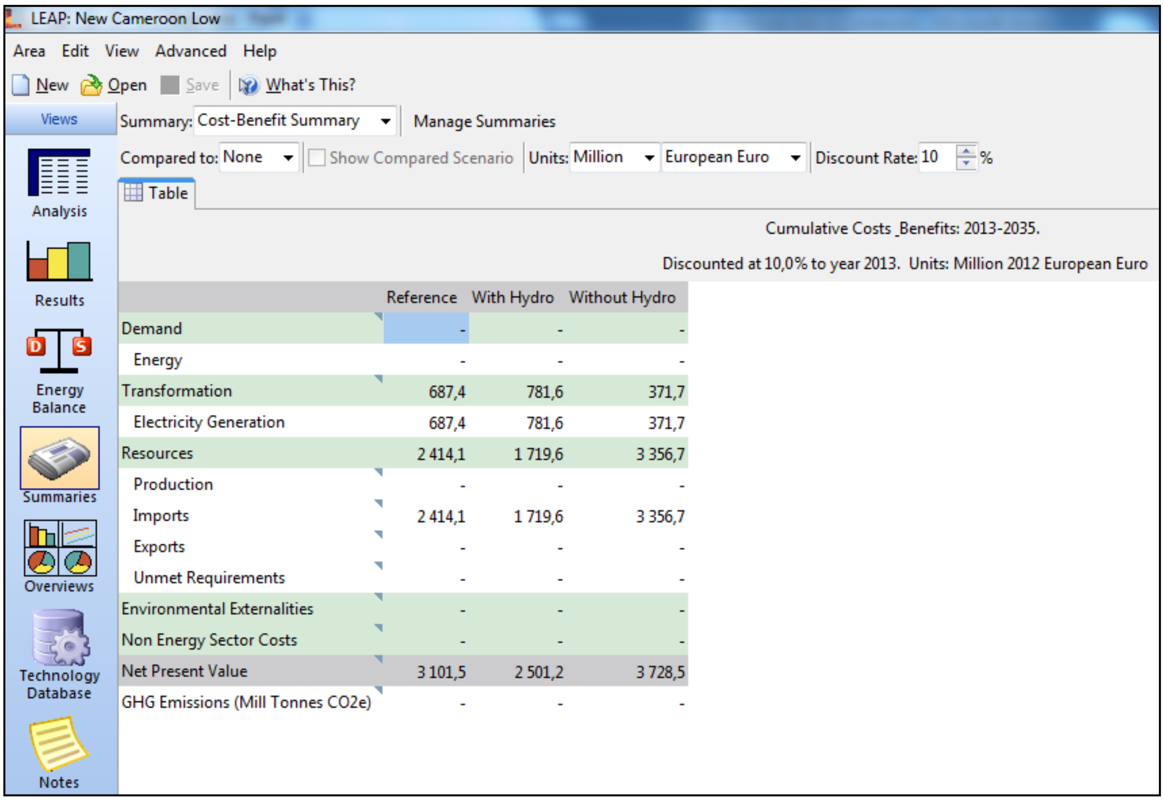
	Reference	With Hydro	Without Hydro
Demand	-	-	-
Energy	-	-	-
Transformation	1 955,0	1 945,1	764,8
Electricity Generation	1 955,0	1 945,1	764,8
Resources	2 373,2	1 556,7	4 507,2
Production	-	-	-
Imports	2 373,2	1 556,7	4 507,2
Exports	-	-	-
Unmet Requirements	-	-	-
Environmental Externalities	-	-	-
Non Energy Sector Costs	-	-	-
Net Present Value	4 328,2	3 501,7	5 272,0
GHG Emissions (Mill Tonnes CO2e)	-	-	-

Table B4: Screenshot of the result of LEAP calculation for the Median scenario – The savings in total cost with hydro plants is ΔTC = 1770.3 M€



	Reference	Without Hydro
Demand	-	-
Energy	-	-
Transformation	9,9	-1 180,3
Electricity Generation	9,9	-1 180,3
Resources	816,6	2 950,5
Production	-	-
Imports	816,6	2 950,5
Exports	-	-
Unmet Requirements	-	-
Environmental Externalities	-	-
Non Energy Sector Costs	-	-
Net Present Value	826,5	1 770,3
GHG Savings (Mill Tonnes CO2e)	-	-
Cost of Avoiding GHGs (European Euro/Tonne CO2e)	n/a	n/a

Table B5: Screenshot of the result of LEAP calculation for the Low scenario



LEAP: New Cameroon Low

Area Edit View Advanced Help

New Open Save What's This?

Summary: Cost-Benefit Summary Manage Summaries

Compared to: None Show Compared Scenario Units: Million European Euro Discount Rate: 10 %

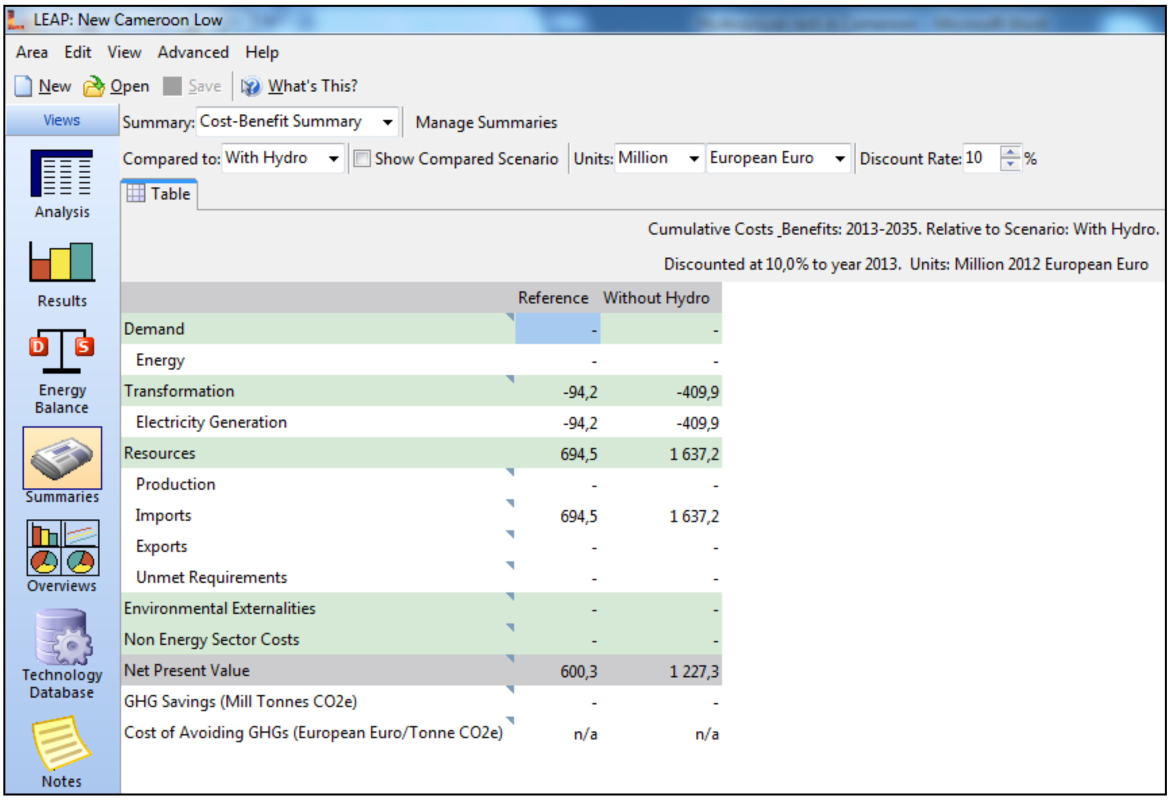
Table

Cumulative Costs _Benefits: 2013-2035.

Discounted at 10,0% to year 2013. Units: Million 2012 European Euro

	Reference	With Hydro	Without Hydro
Demand	-	-	-
Energy	-	-	-
Transformation	687,4	781,6	371,7
Electricity Generation	687,4	781,6	371,7
Resources	2 414,1	1 719,6	3 356,7
Production	-	-	-
Imports	2 414,1	1 719,6	3 356,7
Exports	-	-	-
Unmet Requirements	-	-	-
Environmental Externalities	-	-	-
Non Energy Sector Costs	-	-	-
Net Present Value	3 101,5	2 501,2	3 728,5
GHG Emissions (Mill Tonnes CO2e)	-	-	-

Table B6: Screenshot of the result of LEAP calculation for the Low scenario – The savings in total cost with hydro plants is ΔTC = 1227.3 M€



LEAP: New Cameroon Low

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Summary: Cost-Benefit Summary Manage Summaries

Compared to: With Hydro Show Compared Scenario Units: Million European Euro Discount Rate: 10 %

Table

Cumulative Costs _Benefits: 2013-2035. Relative to Scenario: With Hydro.

Discounted at 10,0% to year 2013. Units: Million 2012 European Euro

	Reference	Without Hydro
Demand	-	-
Energy	-	-
Transformation	-94,2	-409,9
Electricity Generation	-94,2	-409,9
Resources	694,5	1 637,2
Production	-	-
Imports	694,5	1 637,2
Exports	-	-
Unmet Requirements	-	-
Environmental Externalities	-	-
Non Energy Sector Costs	-	-
Net Present Value	600,3	1 227,3
GHG Savings (Mill Tonnes CO2e)	-	-
Cost of Avoiding GHGs (European Euro/Tonne CO2e)	n/a	n/a

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